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ABSTRACT

In this speech, the author traces the history of lighting in schools, discusses the variables affecting the amount of illuminance needed, and provides a table of illuminances recommended for Ontario schools. Other factors that affect vision--glare, veiling reflection, color, and brightness balance--are outlined. Planners are admonished to recognize the needs of visually handicapped students when planning school lighting. Following this is an explanation of the characteristics and uses of the three categories of lamps used in school lighting: incandescent; fluorescent; and high intensity discharge with its mercury, metal halide, and high and low pressure sodium types. The author then deals with windows and daylight, how to control sunlight, and designing for new schools. The relation between light and health and lighting for plant growth are briefly discussed. In closing, practices are listed to make the most of existing systems. (MLF)

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LIGHTING FOR OUR SCHOOLS

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LIGHTING FOR OUR SCHOOLS

HISTORICALLY WE MUST GO BACK TO THE GOLDEN AGE OF GREECE, WHERE CLASSES WERE HELD OUT OF DOORS, SOMETIMES IN THE SHADE TO AVOID THE HEAT OF THE SUN, WITH TEACHERS SUCH AS HIPOCRATES OR ARCHIMEDES, WHO WALKED WITH THEIR STUDENTS AROUND THEIR COMMUNITIES, AND DISCUSSED THE TOTAL ENVIRONMENT.(1) FREQUENTLY A LARGE ROCK SERVED AS THE TEACHER'S POST AND THE STUDENTS GATHERED AROUND THE TEACHER. LESSONS WERE DEMONSTRATIONS AND WERE SCRATCHED INTO THE SAND OR MUD OF THE AREA IN WHICH THEY FOUND THEMSELVES. TYPICALLY, BY THE WAY, THE PUPIL/TEACHER RATIO WAS 17 to 1.

THIS, OF COURSE, WAS A TACIT RECOGNITION OF THE IMPOSSIBILITY OF PROVIDING TOTAL ENCLOSURES SPECIFICALLY FOR LEARNING. IT WAS ALSO THE RECOGNITION OF THE LIMITATION OF ANY ARTIFICIAL ILLUMINATION SOURCE WHICH WOULD ALLOW THESE SESSIONS TO TAKE PLACE IN OTHER THAN DAYLIGHT HOURS.(2) FOR INSTANCE IN AN OUTDOOR THEATRE. THEN WE MOVE FORWARD RAPIDLY THROUGH TIME TO THE MEDIEVAL PERIOD. THE MAIN SOURCE OF KNOWLEDGE WAS RETAINED IN THE MONASTERIES AND THE INFORMATION WAS LABOURIOUSLY COPIED BY

HAND (3) FROM MANUSCRIPT TO MANUSCRIPT, MANY OF WHICH SURVIVE TODAY. THESE ARE MORE WORKS OF ART THAN AN INFORMATION MEDIA, THEN MR. GUTTENBURG INVENTED HIS PRESS. (4)

LATER IN THAT PERIOD, WHEN EDUCATION BEGAN TO BE RECOGNIZED AS A NECESSITY, IN ENGLAND FOR EXAMPLE, TUTORS WERE PROVIDED FOR THE CHILDREN OF THE GENTLEFOLK. IT WAS DISCOVERED THAT THE CHILDREN IN THE WORKHOUSE COULD BECOME MUCH MORE EFFECTIVE IF THEY WERE GIVEN SOME BASIC TRAINING. TYPICALLY THIS WAS GIVEN IN A SQUARISH ROOM WITH LARGE WINDOWS, USUALLY HAVING A HIGH SILL WHICH WAS ESTABLISHED IN ORDER TO MAKE IT MORE DIFFICULT FOR THE CHILDREN TO ESCAPE. THESE WERE NOT SPACES DESIGNED FOR LEARNING BUT FOR CONTAINING THE CHILDREN. LATER IT WAS RECOGNIZED THAT THE CHILDREN COULD PRODUCE USEFUL WORK DURING THE DAY AND THE WHALE-OIL LAMP AND SUBSEQUENTLY THE KEROSENE LAMP WAS USED TO SUPPLEMENT POOR EVENING LIGHTING SO THAT THE CHILDREN COULD GAIN SOME CHANCE OF LOOKING AT THEIR TEXT MATERIALS AND/OR SEE THEIR INSTRUCTOR. (5) (YOU WILL NOTE THAT THESE SCHOOLS NOT ONLY HAD AN ECCLESIASTICAL FLAVOUR BUT WERE RESIDENTIAL. ONLY SELECTED CHILDREN WERE GIVEN THE BENEFIT OF THE TRAINING AND THE EXAMINATION PROCESS).

IN VICTORIAN NORTH AMERICA, SUBSEQUENT TO WHAT MY GRANDFATHER DESCRIBED AS 'THE LATE UNPLEASANTNESS', THIS OF COURSE WAS THE DISAGREEMENT BETWEEN THE UNITED STATES AND CANADA ALSO KNOWN AS THE WAR OF 1812, IT BECAME GENERALLY RECOGNIZED THAT UNIVERSAL EDUCATION HAD SOME SOCIETAL MERITS. THIS LED TO THE ONE ROOM SCHOOL HOUSE, AN APPROXIMATION OF OUR CURRENT SCHOOL YEAR AND AN INCREASING LITERACY OF THE POPULATION OF NORTHEASTERN CONTINENTAL UNITED STATES AND CANADA.

IN OUR COUNTRY, AS YOU ARE AWARE, EDUCATION IS A PROVINCIAL RESPONSIBILITY UNDER OUR CONSTITUTION. THIS WAS MERELY A RECOGNITION OF THE EXISTING PRACTICE THAT WAS IN PLACE LONG BEFORE WE BECAME A COUNTRY. THE SCHOOLS WERE ORGANIZED UNDER TOWNSHIP ADMINISTRATION AND DUE TO THE SCATTERED POPULATION OF THE TIMES THE ONE ROOM SCHOOL HOUSE PREDOMINATED. (6) I HAVE REVIEWED SOME OF THE ORIGINAL RECORDS IN THE ONTARIO ARCHIVES AND DISCOVERED THAT IN ONE, ONE ROOM SCHOOL DURING THE PERIOD FROM 1850 TO 1870, THE SCHOOL HOUSE WHICH MEASURED 24 FEET BY 32 FEET, HAD A SCHOOL POPULATION WHICH VARIED FROM THIRTY TO SEVENTY-EIGHT. THE AVERAGE ATTENDANCE DURING ANY ONE SCHOOL YEAR HOWEVER

SEEMED TO BE IN THE NEIGHBOURHOOD OF THIRTY-FOUR TO THIRTY-SIX. IN THE COMMENT COLUMN THE REASON FOR POOR ATTENDANCE WAS GIVEN IN MANY CASES AS INDIFFERENCE. LIKE TODAY?

THESE SCHOOL HOUSES WERE DESIGNED WITH HIGH WINDOWS AND HIGH SILLS SO THAT THE CHILDREN WOULD NOT BE DISTRACTED BY LOOKING AT THE OUTSIDE ENVIRONMENT AND ALSO TO ALLOW MAXIMUM DAYLIGHT PENETRATION INTO THE SPACE. THERE WAS ALSO RECOGNITION OF THE EFFECTS OF THE COLD NORTH AMERICAN WINTER AS THERE WERE ONLY SIX WINDOWS, APPROXIMATELY THIRTY INCHES BY SIXTY INCHES AND THESE OF COURSE WERE DOUBLE GLAZED. THERE WAS A COLD VESTIBULE AT THE ENTRANCE TO BREAK THE WINTER WINDS AND A WOOD, BOX STOVE SAT IN THE CENTER OF THE ROOM TO PROVIDE THE NECESSARY HEAT. (7) ARTIFICIAL LIGHTING WAS PROVIDED BY OIL LAMPS WHICH WERE USED AS LITTLE AS POSSIBLE IN ORDER TO KEEP DOWN EXPENSES.

THE FIRST MAJOR DEVELOPMENT IN ARTIFICIAL LIGHTING WAS THE INTRODUCTION FIRST OF THE CARBON FILAMENT AND LATER THE TUNGSTEN FILAMENT, INCANDESCENT ELECTRIC LAMP. THE DISTRIBUTION OF ELECTRICAL POWER, WHICH STARTED, IN OUR AREA, JUST AFTER THE

TURN OF THE CENTURY, GRADUALLY BECAME GENERAL THROUGHOUT NORTH AMERICA AFTER THE FIRST WORLD WAR. TYPICALLY, CLASSROOM LIGHTING DESIGN CONSISTED OF FOUR, OR SOMETIMES SIX IN WEALTHY AREAS, PENDANT, BARE LAMP FIXTURES. HOWEVER, DAYLIGHT REMAINED THE PRINCIPLE LIGHT SOURCE. LATER, IN THE EARLY TWENTIES, THESE CAME TO BE ENCLOSED IN GLASS SHADES (8) WHICH WERE DESIGNED TO REDUCE THE BRIGHTNESS OF THE SOURCE. GLASS DESIGN FOR LUMINAIRES IMPROVED GRADUALLY DURING THE DEPRESSION (9) BUT THE LIGHTING LEVELS THAT WERE INSTALLED WITHIN LEARNING SPACES DID NOT REALLY VARY UNTIL THE INTRODUCTION OF THE TUBULAR FLUORESCENT LAMP DURING THE LATER PART OF THE SECOND WORLD WAR.

COINCIDENT WITH THE IMPROVED DESIGN EFFICIENCY OF ARTIFICIAL LIGHTING LUMINAIRES, WAS THE INCREASING AMOUNT OF GLASS WHICH WAS ADDED, OR SHOULD I SAY INSERTED, INTO THE EXTERIOR WALLS OF OUR SCHOOLS. CEILING HEIGHTS AVERAGED TWELVE TO FOURTEEN FEET AND WINDOWS WERE, IN MANY CASES, A MINIMUM OF EIGHT FEET TALL IN ORDER TO ALLOW THE GREATEST POSSIBLE PENETRATION OF DAYLIGHT. THIS CONTINUED UNTIL AFTER THE SECOND WORLD WAR. IMPROVED, MECHANICALLY CIRCULATED HEATING ALLOWED US TO ALMOST IGNORE OUR CLIMATE.

WITH THE ADVENT OF MASS PRODUCED FLUORESCENT LAMPS, HIGHLY EFFICIENT LAMPS, COMPARED TO INCANDESCENT LAMPS, THE PREVIOUS RESTRICTIONS ON CLASSROOM LIGHTING DISAPPEARED. NOW IT BECAME CHEAP ENOUGH TO HAVE VIRTUALLY AS MUCH LIGHT AS WE WANTED, WHENEVER WE WANTED IT.

NOT TOO MANY YEARS AGO, WHEN ENERGY WAS SIGNIFICANTLY CHEAPER THAN IT IS NOW. IT WAS FREQUENTLY RECOMMENDED THAT FLUORESCENT LAMPS BE LEFT BURNING TWENTY-FOUR HOURS A DAY AS THE COST OF THE POWER CONSUMED WAS LESS THAN THE COST OF THE LABOUR AND LAMPS TO REPLACE THEM AS THEIR LIFE SPAN IS AFFECTED BY SWITCHING.

NOW, FOR TODAY, WHAT ARE WE AFTER? FIRST, THE GOAL OF SCHOOL LIGHTING MUST BE TO CONTRIBUTE TO THE CREATION OF AN EFFECTIVE, TOTAL VISUAL ENVIRONMENT FOR LEARNING. THE VISUAL ENVIRONMENT INCLUDES ALL PORTIONS OF THE MILIEU IN WHICH A VISUAL TASK CAN TAKE PLACE. THE VISUAL TASK, OF COURSE, IS THAT PART OF THE TOTAL TASK THAT DEPENDS ON SIGHT. THIS MAY BE A LARGE OR SMALL PART OF THE PARTICULAR ACTIVITY.

HOW MUCH LIGHTING IS ENOUGH LIGHTING? WHAT OTHER QUALITIES ARE REQUIRED? WE ALL KNOW THAT EVEN IF THE LIGHTING IS PROPERLY DESIGNED, WE CANNOT HOPE TO ACHIEVE THE INTENSITY WHICH ONE EXPERIENCES OUT OF DOORS, EVEN ON A DAY WITH A LIGHTLY OVERCAST SKY. THIS IS IN THE NEIGHBOURHOOD

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OF EIGHT THOUSAND PLUS FOOT CANDLES OR TEN THOUSAND LUX.

FIRST WE MUST LOOK AT THE AGE, THE TASK AND THE SKILL OF THE OCCUPANT OF THE SPACE. RESEARCH INDICATES THAT AGE,EXPERIENCE AND FATIGUE GREATLY AFFECT THE QUANTITY OF LIGHT THAT A PERSON NEEDS TO PERFORM A TASK. A SKILLED PERSON NEEDS LESS LIGHT THAN ONE WHO IS UNSKILLED, OR INEXPERIENCED. A YOUNGER PERSON NEEDS LESS LIGHT THAN AN OLDER PERSON, ALL OTHER THINGS BEING EQUAL, TO PERFORM A SPECIFIC TASK. MANY OTHER FACTORS AFFECT THE ABILITY TO SEE.

VISUAL PERFORMANCE IS USUALLY CONSIDERED TO BE A MEASURE OF THE SKILL,SPEED AND EASE WITH WHICH THE VISUAL PORTION OF A TASK IS COMPLETED. VISUAL PERFORMANCE IS IMPROVED IF THERE IS A GOOD CONTRAST BETWEEN THE TASK AND ITS BACKGROUND; IF THERE IS NO SEVERE GLARE FROM THE LUMINAIRES OR OTHER LIGHT SOURCE WHICH WOULD INCLUDE SUNSHINE AND IF THERE IS AN INCREASE IN THE ILLUMINANCE PROVIDED. A PERSON WITH NORMAL SIGHT BENEFITS FROM INCREASED ILLUMINANCE. THAT IS, HE OR SHE SEES FASTER AND MORE ACCURATELY. THE QUESTION THAT ARISES, OF COURSE, IS OF THE AMOUNT OF IMPROVEMENT IN PERFORMANCE IN RELATION TO THE INCREASE IN ENERGY EXPENDITURE AND HENCE COST. THIS COST INCLUDES BOTH CAPITAL AND OPERATING COSTS.

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CONTINUING RESEARCH HAS SHOWN THAT THE FUNDAMENTAL SYSTEM USED UNTIL RECENTLY TO ESTABLISH ILLUMINANCE RECOMMENDATIONS CANNOT BE COMPLETELY AND SCIENTIFICALLY SUPPORTED. A NEW SYSTEM BASED ON RIGOROUS RESEARCH IS AT LEAST TEN YEARS AWAY. CONSEQUENTLY ANOTHER APPROACH HAS BEEN ADOPTED BY THE I E S (ILLUMINATING ENGINEERING SOCIETY) BASED NOT ON RESEARCH BUT ON CONSENSUS, A MAJORITY AGREEMENT OF INDIVIDUALS, KNOWLEDGEABLE IN LIGHTING RESEARCH AND APPLICATION.

YOU SEE HERE (10) A TABLE OF RECOMMENDED ILLUMINANCES WHICH THE PROVINCE OF ONTARIO IS RECOMMENDING FOR SCHOOLS IN OUR JURISDICTION. IT WAS ARRIVED AT BY TAKING THE I E S CATEGORIES, USING APPROPRIATE WEIGHTING FACTORS, AND RESOLVING THEM INTO THE NUMBERS WHICH YOU SEE BEFORE YOU. THESE HAVE, BY THE WAY, BEEN REVIEWED CAREFULLY BY EXPERTS IN YOUR COUNTRY, IN ENGLAND, IN UNESCO AS WELL AS AT HOME AND HAVE BEEN FOUND SATISFACTORY. FOR THOSE OF YOU WHO ARE MORE COMFORTABLE IN THE IMPERIAL SYSTEM OF MEASURE, YOU MERELY DIVIDE THESE NUMBERS BY 10.76 TO ARRIVE AT FOOT CANDLES.

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FREQUENTLY SOME OF OUR SCHOOL SPACES ARE REQUIRED TO SERVE MORE THAN ONE FUNCTION, IN THESE CASES MULTIPLE LEVELS OF ILLUMINANCE MAY WELL BE AN ECONOMICAL APPROACH TO MEET THE VARYING NEEDS. TRADITIONALLY WE HAVE MERELY PROVIDED AS MUCH ILLUMINANCE AS WAS REQUIRED FOR THE MORE DIFFICULT TASK OR FOR THE OLDER OCCUPANT AND ALLOWED IT TO BE USED CONTINUOUSLY. SWITCHING OR DIMMING MAY BE UTILIZED TO GIVE SOME VARIATION IN ILLUMINANCE LEVELS AND WE WILL DISCUSS THAT LATER.

IN RECENT YEARS E.S.I. (EQUIVALENT SPHERE ILLUMINATION) HAS BEEN PUT FORWARD AS A BETTER METHOD OF SPECIFYING ILLUMINANCE. THIS TAKES INTO ACCOUNT THE EFFECT OF CONTRAST AND GLARE IN THE VISUAL FIELD. SURPRISINGLY FREQUENTLY, THE RECOMMENDED ILLUMINANCE FOR A PARTICULAR VISUAL TASK IS NO GUARANTEE THAT THE TASK WILL BE SEEN WELL. WE ARE ALL FAMILIAR WITH THE EFFECT OF A PATCH OF SUNLIGHT ON A CHALKBOARD, OR THE REFLECTED GLARE ON A WRITING TABLET IN THE SUNSHINE, WHICH MAKES IT IMPOSSIBLE TO READ WHAT IS WRITTEN THEREON, EVEN THOUGH THE LIGHT LEVEL IS MORE THAN ADEQUATE. A SIMILAR, BUT LESS OBVIOUS,PHENOMENA IS THE DIFFERENCE IN THE REFLECTION ON THE SURFACE WHEN THE TEXTURE OF THE MATERIAL

IS GLOSSY AS OPPOSED TO A DULL SURFACE. THIS EFFECT, POSSIBLY UNDETECTABLE BY THE NAKED EYE, IS AS THOUGH A LUMINOUS VEIL WERE SUPERIMPOSED OVER THE VISUAL TASK, HENCE THE NAME VEILING REFLECTION. OFTEN VEILING REFLECTIONS ARISE FROM REFLECTIONS OFF THE VISUAL TASK ITSELF, SUCH AS THE PRINT ON A PAGE. THE PRINT ITSELF BECOMES A SERIES OF TINY MIRRORS WHICH BECOME RELATIVELY BRIGHT. THE EFFECT IS TO REDUCE THE CONTRAST BETWEEN THE PRINT OR WRITING AND THE PAGE, MAKING READING MORE DIFFICULT.

EQUIVALENT SPHERE ILLUMINATION IS A METHOD OF SPECIFYING ILLUMINANCE IN SUCH A WAY THAT IT TAKES CONTRAST INTO ACCOUNT. WE CANNOT RECOMMEND THIS PRACTICE FOR GENERAL USE BECAUSE THERE IS INSUFFICIENT EXPERIENCE OBTAINED WITH E.S.I. TO PERMIT A TOTAL CONCENSUS APPROACH TO ILLUMINANCE RECOMMENDATIONS. FURTHER, IN ORDER TO OBTAIN THE MAXIMUM E.S.I. ON THE VISUAL TASK, THE TASK MUST BE CAREFULLY AND SPECIFICALLY LOCATED WITH REFERENCE TO THE LUMINAIRES AND THE WINDOWS. IN A TYPICAL CLASSROOM, WHERE THE WORKING POSITIONS ARE FREQUENTLY CHANGED, THERE IS NO GUARANTEE THAT THE RESULTING E.S.I. ON A VISUAL TASK, REMOVED FROM ITS CALCULATED SOURCE POINT, WOULD BE AT THE DESIRED LEVEL. BECAUSE OF THE COMPLICATION, E.S.I. REQUIRES A COMPUTER PROGRAM FOR DESIGN CALCULATIONS, AS WELL AS A SPECIFIC SPECIAL PHOTOMETER TO MEASURE THE RESULTS AND A SECOND, BUT SMALLER, COMPUTER PROGRAM TO CONVERT THE PHOTOMETRIC

READINGS INTO E.S.I. FIGURES.

DURING ANY DISCUSSION ON LIGHTING WE MUST BE SURE WE INCLUDE PROVISION FOR VISUALLY IMPAIRED STUDENTS. WE ARE INFORMED THAT ONE HALF OF THE SCHOOL AGE CHILDREN WHO ARE LEGALLY BLIND, AS REGISTERED WITH THE AMERICAN PRINTING HOUSE FOR THE BLIND, HAVE USEFUL VISION AT THE NEAR POINT. THEY ARE THUS ABLE TO USE PRINTED MATERIAL AS THEIR MEANS OF LEARNING. GENERALLY, VISUALLY IMPAIRED STUDENTS BENEFIT FROM INCREASED ILLUMINANCE ALTHOUGH THERE ARE EXCEPTIONS, FOR EXAMPLE PEOPLE WITH CATARACTS.

GLARE; NO DISCUSSION ON LIGHTING CAN AVOID THIS MOST DIFFICULT TOPIC. GLARE OCCURS WHEN THE LUMINANCE - THE BRIGHTNESS - OF SOME PART OF THE FIELD OF VIEW IS SUBSTANTIALLY GREATER THAN THAT IN OTHER PARTS. GLARE TAKES TWO FORMS.

FIRST, IT CAN REDUCE THE ABILITY TO SEE. THIS IS CALLED "DISABILITY GLARE". IT COMMONLY OCCURS WHEN A BRIGHT LIGHT IS REFLECTED OFF A SURFACE. DISABILITY GLARE CAN BE CAUSED BY SUN SHINING ON A CHALKBOARD. TEACHERS MAY BE UNAWARE OF THE PROBLEM BECAUSE THEY

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PLACE THEMSELVES IN A POSITION WHERE THEY CAN SEE WELL, LITTLE REALIZING THE VISUAL DIFFICULTIES SOME STUDENTS MAY BE EXPERIENCING.

SECONDLY THERE IS DISCOMFORT GLARE. THIS MAY BE PRESENT WITHOUT REDUCING THE ABILITY TO SEE. THIS IS PARTICULARLY TRUE IN VERY BRIGHT SURROUNDINGS WHICH RESULT FROM A LIBERAL DISPLAY OF BRIGHT LUMINAIRES. DISCOMFORT GLARE IS A FUNCTION OF THE LUMINANCE, THE SIZE OF THE LUMINAIRE, AND OF THE NUMBER OF LUMINAIRES IN THE FIELD OF VIEW. THE BRIGHTER THE LUMINAIRE, OR THE BIGGER IT IS, OR THE GREATER THE NUMBER OF LUMINAIRES SEEN, THE GREATER THE DISCOMFORT GLARE THAT WILL BE CAUSED. THE INFLUENCE OF THE LUMINANCE OF THE FIXTURE IS PARTICULARLY SIGNIFICANT. IF THE LUMINANCE IS DOUBLED AND ALL OTHER FACTORS HELD CONSTANT, THE GLARE EFFECT WILL BE MORE THAN TREBLED.

COLOUR MAY ALSO BE A CONTRIBUTING FACTOR. DISCOMFORT GLARE CAN BE REDUCED IF LIGHT COLOURS ARE USED. A LUMINAIRE THAT CAN CAUSE INTENSE DISCOMFORT IN A SPACE WITH DARK WALLS,MAY BE INOCUOUS IF THE WALLS ARE PAINTED A LIGHT COLOUR.

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INDIRECT LIGHTING, WHICH FREQUENTLY HAS A SOFT DIFUSE QUALITY AND THE LAMP IS COMPLETELY SCREENED FROM VIEW, CAN, NEVERTHELESS, CAUSE GLARE. RECENTLY THE USE OF HIGH INTENSITY DISCHARGE LAMPS SUCH AS MERCURY OR HIGH PRESSURE SODIUM HAVE FOUND THEIR WAY INTO GENERAL LIGHTING SYSTEMS. THESE CAN CREATE A VERY BRIGHT SPOT ON THE CEILING WHICH DEVELOPS DISCOMFORT GLARE, PARTICULARLY WHEN AN INDIRECT SYSTEM IS USED AND THE FIXTURES ARE CLOSE TO THE CEILING. ONE SIMPLE WAY OF APPRAISING AN EXISTING LIGHTING SYSTEM FOR DISCOMFORT GLARE IS TO SELECT A TYPICAL POSITION IN A SPACE AND SHADE YOUR EYES WITH A HAND HELD HORIZONTALLY.(11) IF, AS A RESULT, THE LIGHTING SUDDENLY BECOMES MORE COMFORTABLE, THEN THE LIGHTING SYSTEM IS LIKELY TO BE TOO GLARING. OBVIOUSLY THIS DOES NOT DETERMINE WITH PRECISION HOW MUCH DISCOMFORT GLARE CAN BE REDUCED, BUT IT IS A VALID TEST. SIMILARLY IN THE TYPICAL CLASSROOM SITTING BESIDE THE TRADITIONAL SILL TO CEILING GLASS WALL THE HAND HELD VERTICALLY MAY, IN FACT, MAKE IT EASIER TO SEE.

BRIGHTNESS BALANCE IS ANOTHER FACTOR IN THE ABILITY TO SEE. AND THE OCCUPANT'S PERCEPTION OF THE ENVIRONMENT AS A CHEERFUL OR PLEASANT PLACE IN WHICH TO LEARN. A CLASSROOM WITH DARK WALLS AND DARK FURNITURE, SUCH AS THOSE FOUND IN SOME OF OUR OLDER

UNIVERSITIES, WILL BE A GLOOMY SPACE WHATEVER THE ILLUMINANCE. A PROPER BALANCE OF BRIGHTNESS LEVELS MUST BE MAINTAINED. A SUBSTANTIAL DIFFERENCE IN BRIGHTNESS BETWEEN THE VISUAL TASK AND THE ARE/ IMMEDIATELY SURROUNDING IT, OR LARGE ADJACENT AREAS IN THE FIELD OF VIEW MAY WELL CREATE VISUAL DISCOMFORT. A QUICK RULE OF THUMB IS THAT THE BACKGROUND LEVEL SHOULD NEVER BE LESS THAN 30% OF THE LEVEL ON THE TASK. COLOUR CONTRAST, ON THE OTHER HAND IS RECOMMENDED AS A MEANS TO MAKE A SPACE MORE CHEERFUL.

COLOUR CHOICES, HOWEVER, DO NOT ALWAYS APPEAR TO PRODUCE THE EXPECTED EFFECT, PARTICULARLY WHERE THE COLOURS DO NOT SEEM ATTRACTIVE UNDER CERTAIN LIGHT SOURCES. YOU THEREFORE, MUST, BE SURE THAT THE LIGHT SOURCES CHOSEN WILL PERMIT THE DESIRED COLOUR EFFECTS WITHIN THE SPACE. THE APPEARANCE OF A LIGHT SOURCE IS NOT NECESSARILY ANY HELP IN THIS MATTER AS THE COLOUR OF THE LAMP GIVES NO INDICATION HOW COLOURED OBJECTS WILL APPEAR UNDER IT. TWO LAMPS MAY LOOK THE SAME COLOUR BUT HAVE DIFFERENT COLOUR RENDERING FACTORS, FOR EXAMPLE COOL WHITE AND DELUXE COOL WHITE LAMPS LOOK MUCH THE SAME. UNDER THE COOL WHITE LAMP YELLOWS BECOME PARTICULARLY VIVID AND THE REDS ARE GREYED; UNDER THE

DELUXE COOL WHITE LAMP THESE EFFECTS DO NOT OCCUR.

LAMPS WITH GOOD COLOUR RENDERING ARE ESSENTIAL FOR SCHOOL ACTIVITIES IN WHICH THE EFFECT OF COLOUR HAS A MAJOR IMPACT ON THE STUDENTS' RESPONSE-ART CLASSES ARE AN OBVIOUS EXAMPLE. THE SAME APPLIES TO COOKING CLASSES AND CAFETERIAS. EVEN THE BEST OF FOOD LOOKS UNAPPETIZING UNDER THE WRONG LAMPS. IT IS ALSO IMPORTANT TO USE GOOD COLOUR RENDERING LAMPS IN LOWER GRADES WHERE CHILDREN ARE TAUGHT THE RECOGNITION OF COLOURS AND THEIR RELATIONSHIP TO OBJECTS OF THE WORLD. WHENEVER COLOURS ARE SELECTED FOR A BUILDING THEY SHOULD BE CHOSEN UNDER THE LIGHT OF LAMPS WHICH WILL BE IN THE SPACE IN WHICH THE COLOURS ARE TO BE SEEN.

THERE ARE THREE CATEGORIES OF LAMPS USED GENERALLY IN SCHOOL LIGHTING, INCANDESCENT, FLUORESCENT AND HIGH INTENSITY DISCHARGE. THERE ARE DIFFERENT DESIGN CHARACTERISTICS, OF COURSE, FOR EACH LAMP, EACH HAS ITS PLACE. (12)

THE INCANDESCENT LAMP IS THE ONE IN MOST COMMON HOUSEHOLD USE. THIS CONSISTS OF A FILAMENT OF FINE TUNGSTEN WIRE COILED AND ENCLOSED IN A GLASS BULB WHICH IS USUALLY FILLED WITH A MIXTURE OF NITROGEN AND ARGON. ELECTRIC CURRENT PASSING THROUGH THE FILAMENT HEATS IT UNTIL IT GIVES OFF LIGHT. A VARIATION OF THIS

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IS THE TUNGSTEN HALOGEN LAMP WHERE THE FILAMENT IS MAINTAINED IN A QUARTZ ENVELOPE IN AN ATMOSPHERE OF IODINE VAPOUR INSTEAD OF NITROGEN/ ARGON. THIS INCREASES THE FILAMENT LIFE AND REDUCES THE DARKENING COMPARED TO OTHER INCANDESCENT LAMPS, HOWEVER IT COSTS SIGNIFICANTLY MORE

THE EFFICACY OF AN INCANDESCENT LAMP, THAT IS THE LUMENS OF LIGHT PER WATT OF POWER, INCREASES AS THE LAMP WATTAGE INCREASES. HOWEVER, FOR A GIVEN LAMP, THE EFFICACY CAN BE INCREASED ONLY IF A SHORTER LAMP LIFE IS ACCEPTABLE; A LONGER LIFE IS ACHIEVED BY A REDUCTION IN EFFICACY. FOR EXAMPLE A STANDARD 100 WATT LAMP HAS A RATED LIFE OF 750 HOURS. THE EXTENDED 100 WATT LAMP HAS A RATED LIFE OF 2500 HOURS. THIS INCREASE IS ACHIEVED AT THE EXPENSE OF A DROP IN EFFICACY FROM 17.5 LUMENS PER WATT TO 15 LUMENS PER WATT. THE RATED LIFE OF ANY LAMP DOES NOT MEAN THAT EVERY LAMP WILL BURN FOR THAT PERIOD OF TIME. AT THE RATED LIFE, FIFTY PERCENT OF THE LAMPS IN A LARGE INSTALLATION WILL HAVE FAILED. THIS SHOULD BE BORN IN MIND WHEN ESTABLISHING BUDGETS AND MAINTENANCE SCHEDULES.

FLUORESCENT LAMPS - THE FLUROESCENT LAMP CONSISTS OF A GLASS TUBE CONTAINING MERCURY VAPOUR WITH ELECTRODES AT EACH END. THE INSIDE OF THE TUBE IS COATED WITH A POWDER WHICH IS PHOSPHOR.

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AN ARC FLASHES TO AND FRO BETWEEN THE ELECTRODES PRODUCING INVISIBLE ULTRA-VIOLET RADIATION TOGETHER WITH A LITTLE VISIBLE BLUE LIGHT. THE RADIATION FALLS ON THE PHOSPHORS COATING THE TUBE CAUSING THEM TO FLUORESCE AND GIVE OFF LIGHT. MOST OF THE ULTRA-VIOLET RADIATION IS THUS ABSORBED BY THE PHOSPHORS AND THE GLASS TUBE, LITTLE BEING EMITTED BY MOST LAMPS. LIGHT OF ALMOST ANY COLOUR CAN BE PRODUCED BY USING THE APPROPRIATE PHOSPHORS.

FLUORESCENT LAMPS RANGE IN SIZE FROM 4 WATTS TO 215 WATTS. REDUCED WATTAGE LAMPS HAVE BEEN INTRODUCED IN THE PAST FEW YEARS. THEY USE 10% TO 20% LESS POWER THAN THE CORRESPONDING STANDARD FLUORESCENT LAMPS, DEPENDING ON SIZE. ONE WHICH IS COMMONLY USED IN SCHOOLS IS THE 35 WATT RAPID START LAMP WHICH CAN BE SIMPLY SUBSTITUTED FOR THE 40 WATT LAMP WITHOUT CHANGE OF BALLAST.

ONE OF THE THINGS WHICH PERHAPS IS NOT WELL UNDERSTOOD IS THAT THE LIFE OF A FLUORESCENT LAMP IS AFFECTED BY THE NUMBER OF TIMES IT IS SWITCHED ON OR OFF ALMOST REGARDLESS OF THE NUMBER OF HOURS IT IS ON FOR ANY ONE TIME. IN ONTARIO IF THE LAMP WOULD BE ON

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FOR MORE THAN THREE TO FIVE MINUTES IN AN EMPTY CLASSROOM WHETHER FOR RECESS OR ANY OTHER REASON, WE TURN IT OFF.

ANOTHER CHOICE WHICH IS OFFERED TO SCHOOLS AND OTHER USERS TODAY IS THE DUMMY LAMP OR PHANTOM LAMP DEPENDING ON WHOSE TRADE NAME YOU USE. THIS LAMP, IN A TWO LAMP FIXTURE, WILL REDUCE THE AMOUNT OF LIGHT BY APPROXIMATELY 2/3 BUT IT COSTS MORE, ALSO IT REDUCES BY APPROXIMATELY 75% THE POWER DRAWN.

HIGH INTENSITY DISCHARGE LAMPS - THESE ARE CALLED HIDS, IN MOST TECHNICAL PUBLICATIONS. THERE ARE FOUR TYPES: MERCURY, METAL HALIDE, HIGH AND LOW PRESSURE SODIUM. HID LAMPS HAVE BEEN FOUND SATISFACTORY IN MANY SCHOOL LOCATIONS, WITH THE EXCEPTION OF LOW-PRESSURE SODIUM, IN AREAS WHERE COLOUR RENDERING IS NOT THE PRIMARY CRITERIA.

MERCURY LAMPS CONSIST OF TWO ENVELOPES THE OUTER GLASS TUBE AND THE MUCH SMALLER INNER ARC TUBE. THE ARC TUBE CONTAINS MERCURY VAPOUR WHICH EMITS LIGHT WHEN AN ELECTRIC CURRENT IS PASSED THROUGH IT FORMING AN ARC. ULTRAVIOLET RADIATION IS ALSO EMITTED. THIS RADIATION, IN THE FORM OF AN ARC, FALLS ON THE PHOSPHORS COATING

THE INSIDE OF THE OUTER BULB,CAUSING THEM TO EMIT LIGHT. THE LIGHT FROM A MERCURY LAMP IS THUS A COMBINATION OF THAT FROM BOTH THE ARC TUBE AND THE PHOSPHORS.

THE METAL HALIDE LAMP IS SIMILAR IN CONSTRUCTION TO THE MERCURY LAMP. THE MAIN DIFFERENCE IS THAT ITS ARC TUBE CONTAINS METAL HALIDES IN ADDITION TO THE MERCURY VAPOUR. THESE CHANGE THE COLOUR OF THE LIGHT EMITTED FROM THE ARC TUBE FROM THE BLUE OF THE MERCURY ARC TO WHITE. THE COLOUR IS FURTHER IMPROVED IN SOME LAMPS - BY COATING THE INSIDE OF THE OUTER BULB WITH PHOSPHORS, SUCH AS IS FOUND IN THE MERCURY LAMPS. THE EFFICACY OF THE METAL HALIDE LAMP IS 1 1/2 TO 2 TIMES THAT OF THE MERCURY LAMP.

THE HIGH PRESSURE SODIUM LAMP ALSO HAS TWO ENVELOPES. THE OUTER IS OF GLASS AND THE INNER ARC TUBE, WHICH CONTAINS THE SODIUM, IS OF ALUMINA, A MATERIAL THAT IS MORE RESISTANT TO SODIUM ATTACK AT HIGH TEMPERATURES THAN GLASS. THE LIGHT FROM THIS LAMP IS USUALLY DESCRIBED AS BEING "GOLDEN WHITE".

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THE LOW-PRESSURE SODIUM LAMP SIMILARLY HAS TWO ENVELOPES. THE INNER-THE ARC TUBE - IS OF SPECIAL NON-STAINING GLASS CONTAINING SODIUM AND A GAS, WHICH IS USUALLY NEON. THE OUTER ENVELOPE IS A VACUUM JACKET, SIMILAR IN PRINCIPLE TO A THERMOS FLASK. ITS PURPOSE IS TO KEEP THE DISCHARGE IN THE ARC TUBE AT ITS OPTIMUM OPERATING TEMPERATURE. THE LOW PRESSURE SODIUM LAMP IS NOT SUITABLE FOR INTERIOR SCHOOL LIGHTING AS IT GIVES OFF A YELLOW LIGHT WHICH TURNS EVERY COLOUR IT FALLS ON EITHER YELLOW OR MUDDY.

WINDOWS AND DAYLIGHT

WINDOWS HAVE USUALLY BEEN CONSIDERED AN ADVANTAGE IN A SCHOOL. THEY LET LIGHT IN AND ENABLE STUDENTS AND STAFF TO SEE OUT. THERE IS AN INSTINCTIVE DESIRE FOR CONTACT WITH THE OUTSIDE. BY CONTRAST, TEACHERS IN WINDOWLESS SCHOOLS HAVE REFERRED APPROVINGLY TO "NO DIRECT SUNSHINE; NO GLARE; NO OUTSIDE DISTURBANCES - NOISE OR WEATHER CONDITIONS".

HOW EFFECTIVE ARE WINDOWS IN MODERN SCHOOLS IN PROVIDING LIGHT BY WHICH TO WORK AND STUDY? WE NEED TO COLLECT DATA ON THE AMOUNT OF DAYLIGHT AVAILABLE FOR INTERIOR LIGHTING AND THE EXTENT

TO WHICH IT CAN REDUCE LIGHTING AND HEATING COSTS. THERE IS ALSO A NEED TO IMPROVE THE TECHNIQUES BY WHICH INTERIOR DAYLIGHTING IS PREDICTED: ANY EXISTING TECHNIQUES ARE OF LIMITED ACCURACY. WE KNOW, IN A TYPICAL CLASSROOM WITH SILL TO CEILING GLASS RUNNING WALL TO WALL,(13) THAT THE FIRST 10 FEET OF CLASSROOM, MEASURED IN FROM THE WINDOWS, WILL NORMALLY HAVE SUFFICIENT LIGHT MUCH OF THE DAY. THUS, WHERE A CLASSROOM IS ILLUMINATED BY THREE ROWS OF FLUORESCENT LUMINAIRES, THE ROW OR ROWS NEAREST THE WINDOW CAN BE SWITCHED OFF MUCH OF THE TIME.(14)

WINDOWS ARE CAPABLE OF PRODUCING BOTH DISABILITY AND DISCOMFORT GLARE. THE FORMER RESULTING IN REDUCED VISIBILITY AND VISUAL PERFORMANCE ; THE LATTER PRODUCING SKY GLARE. BLINDS AND DRAPES ARE AN EFFECTIVE MEANS OF CONTROLLING THAT GLARE. DIRECT SUNLIGHT ALSO CAUSES A BUILDUP OF HEAT IN CLASSROOMS. ONE SQUARE METRE OF UNSHADED WINDOW CAN TRANSMIT SOLAR RADIATION EQUIVALENT IN HEATING POWER TO ONE SQUARE METRE OF A STEAM RADIATOR.

SUNLIGHT MAY BE CONTROLLED BY EXTERNAL LOUVRES, BY INTERIOR DRAPES, AND BY DEVICES SANDWICHED BETWEEN DOUBLE GLAZING. LOUVRES ARE THE MOST EFFECTIVE, AS IT IS ALWAYS BETTER TO CONTROL THE

SUN BEFORE IT REACHES THE GLASS. MAINTENANCE PROBLEMS FROM ICE AND SNOW MUST BE BORNE IN MIND, HOWEVER, IN THE NORTHERN PARTS OF THE HEMISPHERE. HORIZONTAL LOUVRES CAN BE DESIGNED FOR SOUTH-FACING WINDOWS SO THAT THE SUN IS SCREENED IN THE SUMMER BUT IS ALLOWED TO REACH THE WINDOWS, IN THE WINTER, WHEN AT A LOW ANGLE.

THE GREEK HISTORIAN XENOPHON WHO CHRONICLED THE PELOPONNESIAN WARS AND THE RETREAT OF THE TEN THOUSAND GREEKS FROM PERSIA WROTE, "IN HOUSES WITH A SOUTH ASPECT THE SUNS RAYS PENETRATE INTO THE PORTICOS IN WINTER . IN THE SUMMER THE PATH OF THE SUN IS RIGHT OVER OUR HEADS AND ABOVE THE ROOF SO THAT THERE IS SHADE. IF THEN, THIS IS THE BEST ARRANGEMENT, WE SHOULD BUILD THE SOUTH SIDE LOFTIER TO GET THE WINTER SUN AND THE NORTH SIDE LOWER TO KEEP OUT THE COLD WINDS."

VERTICAL SHADING DEVICES WORK BEST ON WINDOWS FACING APPROXIMATELY EAST AND WEST. UNFORTUNATELY WHAT FREQUENTLY HAPPENS IS THAT THE SCREENING DEVICES, MOST FREQUENTLY

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DRAPES, ARE LEFT CLOSED IN CLASSROOMS FACING SOUTH. THEY ARE LEFT CLOSED BECAUSE OF THE AFOREMENTIONED GLARE PROBLEM AND THE LIGHTING IS LEFT ON FULL-TIME DURING SCHOOL OCCUPANCY.

FOR A NEW SCHOOL WINDOWS AND DAYLIGHT SHOULD BE CONSIDERED AS AN ELEMENT IN LIGHTING DESIGN IN ADDITION TO THE ELECTRIC LIGHTING. GOOD DAYLIGHTING DESIGN DOES NOT SIMPLY MEAN LARGE WINDOWS - IT MUST BE EVALUATED QUANTITATIVELY AND QUALITATIVELY IN BROAD AND SENSITIVE TERMS.(15) FOR EXAMPLE 'THE TEMPLE OF HEAVEN' IN PEKING DEMONSTRATES THAT THE CHINESE HAVE BEEN DOING THIS FOR CENTURIES.

QUANTITATIVE DESIGN OF WINDOWS IS STRAIGHT FORWARD. IT INVOLVES: BUILDING ORIENTATION AND THE DIRECTION IN WHICH THE WINDOWS FACE; THE SIZE, SHAPE, TYPE OF GLAZING OF WINDOWS;SUNLIGHT CONTROL; A TRADE-OFF BETWEEN ENERGY SAVED

BY USING DAYLIGHT INSTEAD OF ELECTRIC LIGHTING AND THE HEAT LOSS OR GAIN THROUGH THE WINDOWS AND ASSESSMENT OF THE COST ELEMENT.

IN CONTRAST TO THIS, QUALITATIVE DESIGN IS COMPLEX. CONSIDERATION MUST BE GIVEN TO MATTERS FOR WHICH THERE ARE NO FIRM DESIGN GUIDELINES. SO FAR, THE SIGNIFICANT CONCLUSION OF STUDIES AIMED AT EVALUATING WHETHER OR NO. SCHOOLS SHOULD HAVE WINDOWS IS, 'THERE IS NO SIGNIFICANT CONCLUSION'. A REVIEW OF THE RESEARCH INDICATES THAT THE ABSENCE OF WINDOWS NEITHER IMPROVES NOR IMPAIRS SCHOLASTIC PERFORMANCE. SOME STUDENTS LIKE WINDOWLESS ENVIRONMENTS WHILE OTHERS, POSSIBLY THE MAJORITY, PREFERRED TO HAVE WINDOWS. WHETHER THIS IS THE FAULT OF THE EXPERIMENTAL DESIGNS USED, OR A REFLECTION OF THE REAL ABSENCE OF ANY PRONOUNCED EFFECT, IS NOT YET KNOWN. THERE ARE SOME EXAMPLES OF ONTARIO ELEMENTARY SPACES WITH MINIMUM OR NO FENESTRATION WHICH ARE DELIGHTFUL TO VISIT OR WORK IN. (16) (17) (18) (19)

LIGHT AND HEALTH

STUDIES ON THE EFFECTS OF LIGHT ON HUMANS ARE INCONCLUSIVE. EXPERIMENTS ON ANIMALS HAVE RECEIVED CONSIDERABLE SCIENTIFIC DISCUSSION, BUT IT IS VERY DIFFICULT TO UNDERSTAND HOW SIGNIFICANTLY THESE FINDINGS CAN BE APPLIED TO HUMAN BEINGS.

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FROM THE SPEAKERS POINT OF VIEW, NO STUDIES, AS YET, HAVE MET RIGOROUS SCIENTIFIC EXPERIMENTAL CRITERIA WHEREBY THE ONLY VARIANT IN THE TOTAL ENVIRONMENT WAS THE TYPE OR COLOUR OR FORM OF LIGHT AND THIS ACHIEVED OVER A SIGNIFICANT, CONTINUOUS PERIOD OF TIME. THE CLOSEST TO WORK IN THE FIELD, THAT WE ARE AWARE OF, HAS BEEN DONE BY THE UNITED STATES NAVY IN SOME OF THE RESEARCH THEY HAVE BEEN DOING FOR NUCLEAR SUBMARINES AND THE ENVIRONMENT IN WHICH SAILORS LIVE AND WORK OVER AN EXTENDED PERIOD. IT WOULD APPEAR THAT THERE IS A DIURNAL EFFECT AS A RESULT OF THE APPARENT PASSAGE OF THE SUN FROM ONE HORIZON TO ANOTHER AND A VARIATION IN LIGHTING, TYPE AND INTENSITY, BASED ON FILTRATION OF THE ATMOSPHERE. HOWEVER THE DIRECT CONNECTION HAS NOT BEEN AS YET ESTABLISHED ON A FORMULA OR MATHEMATICAL BASIS AND THIS WORK, I AM SURE, WILL BE CONTINUED IN THE FUTURE.

ULTRAVIOLET RADIATION DOES AFFECT OUR HEALTH AND ALSO CAUSES SUN-TAN. IT IS PRESENT IN THE SUN'S RAYS AS WELL AS IN MANY COMMONLY USED LAMPS, INCLUDING FLUORESCENT, HID, AND SOME TUNGSTEN-HALOGEN LAMPS. NOT ALL LAMPS EMIT THE SAME UV RADIATION PER WATT OF POWER. THERE IS EVEN CONSIDERABLE VARIATION IN THE

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UV RADIATION FROM THE VARIOUS TYPES OF THE COMMON 4 FOOT 40 WATT FLUORESCENT LAMPS. THE LUMINAIRE IN WHICH A LAMP IS INSTALLED WILL MAKE A DIFFERENCE AS TO THE AMOUNT OF UV RADIATION IT EMITS. FOR EXAMPLE, ANODIZED ALUMINUM IS A GOOD REFLECTOR OF UV RADIATION, WHEREAS GLASS AND MANY PAINTS ABSORB IT. THE ABSENCE OF UV RADIATION CAN CAUSE A DEFICIENCY IN VITAMIN D, HOWEVER THE CLAIMED PROBLEM CAUSED BY SUPPOSED LACK OF UV IN THE LIGHTING OF SOME CLASSROOMS IS REALLY UNWARRRANTED. CHILDREN ARE OUT OF DOORS ON THEIR WAY TO AND FROM SCHOOL, AT RECESSES IN MOST CASES BOTH MORNING AND AFTERNOON AS WELL AS AT THE LUNCH-BREAK AT NOON. OUR INFORMATION IS THAT THE ULTRA-VIOLET RADIATION RECEIVED DURING A 15 MINUTE PERIOD OUT OF DOORS IS MORE THAN ADEQUATE FOR AN INDIVIDUAL IN ANY ONE CALENDAR DAY. MANY SUCCESSFUL SCHOOL LIGHTING INSTALLATIONS USE HID LAMPS. HOWEVER, FROM TIME TO TIME THERE HAS BEEN AN ADVERSE REACTION TO THESE LAMPS, PARTICULARLY TO HIGH-PRESSURE SODIUM. CRITICISM HAS BEEN GENERATED ON -

1. COLOUR OF THE LIGHT FROM THE LAMPS WHICH OF COURSE MAKES ACCURATE COLOUR DISCRIMINATION IMPOSSIBLE AND TENDS TO DISTORT FLESHTONES AND FOOD

2. THE GLARE THEY CAUSE: THIS IS NOT UNIQUE TO HID LIGHTING.
3. THE TIME IT TAKES FOR THE LAMPS TO BURN BRIGHTLY - THAT IS THE STRIKING OR STARTING TIME.
4. THEIR POSSIBLE HEALTH EFFECTS. HEALTH EFFECTS STUDIES HAVE BEEN INCONCLUSIVE.

SOMETIMES IT HAS BEEN STATED THAT WHEN ONE USES GOOD COLOUR RENDERING LAMPS THE ILLUMINANCE IN A WORKING SPACE CAN SAFELY BE LESS THAN THE ILLUMINANCE NEEDED WHEN LAMPS OF POORER COLOUR RENDERING ARE USED. THIS STATEMENT IS INCORRECT. THERE IS NO EVIDENCE TO SHOW THAT THE ILLUMINANCE FOR A VISUAL TASK DEPENDS ON THE COLOUR RENDERING PROPERTIES OF THE LAMPS USED TO LIGHT THE TASK. HOWEVER, FOR SATISFACTORY APPEARANCE, ONE NEEDS LESS LIGHT FROM LAMPS WITH GOOD COLOUR RENDERING.

LAMP FLICKER

FLUORESCENT AND HID LAMPS TEND TO FLICKER AS THEY GET OLD. CHILDREN ARE MUCH MORE SENSITIVE TO FLICKER THAN ADULTS. THE ONSET OF FLICHER MAY WELL BE THE SIGNAL TO CHANGE A LAMP EVEN THOUGH IT HAS NOT YET REACHED THE END OF ITS RATED LIFE.

THERE ARE SOME SPECIAL LIGHTING REQUIREMENTS WHICH WE SHOULD TOUCH ON, SUCH AS LIGHTING FOR AN AREA WITH VISUAL DISPLAY UNITS. REFLECTIONS OF BRIGHT SURFACES, LUMINAIRES OR WINDOWS ON THE SCREEN WILL DILUTE, OR EVEN OBSCURE, THE IMAGES OF THE DATA APPEARING ON THE SCREENS. IT IS ALSO NECESSARY TO AVOID TOO HIGH A BRIGHTNESS CONTRAST BETWEEN THE VIEWER SCREEN AND THE OTHER SURFACES, OTHERWISE THE EYE WILL TIRE AS IT ADAPTS FIRST TO ONE BRIGHTNESS AND THEN TO THE OTHER.

LIGHTING FOR PLANT GROWTH

THERE ARE MANY TYPES OF INCANDESCENT, FLUORESCENT, AND HID LAMPS WHICH ARE USED TO GROW PLANTS INDOORS. PARTICULAR ATTENTION MUST BE PAID TO ENSURE THAT THERE IS ENOUGH ENERGY IN THE RED AND BLUE PARTS OF THE SPECTRUM. A WIDE SPECTRUM FLUORESCENT LAMP IS MADE TO MEET THE SPECIAL REQUIREMENTS OF INDOOR PLANT GROWING.

NO DISCUSSION ON LIGHTING WOULD BE COMPLETE WITHOUT THE MENTION OF SWITCHING AND ENERGY MANAGEMENT OF LIGHTING SYSTEMS.

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MANUAL SWITCHING SHOULD AT LEAST PERMIT SEPARATE CONTROL OF THE ROWS OF LUMINAIRES PARALLEL TO WINDOWS IN CLASSROOMS AS SHOWN EARLIER. WHERE MULTIPLES OF ILLUMINATION ARE DESIRED, - AREAS SUCH AS GENERAL PURPOSE ROOMS, CAFETERIAS, OR GYMNASIA. SWITCHING OF THE ADDITIONAL LIGHTING SHOULD BE AVAILABLE TO THE OCCUPANT. ANOTHER OPTION, THAT CAN BE CONSIDERED FOR CLASSROOMS WITH LUMINAIRES IN ROWS PARALLEL TO THE WINDOW, IS THE PHOTOELECTRIC CONTROL WHICH CAN ENSURE THAT THE ELECTRIC LIGHTING IS NEITHER SWITCHED ON, NOR REMAINS ON, WHEN DAYLIGHT PROVIDES THE REQUIRED ILLUMINATION. WHERE PHOTOELECTRIC CONTROL IS SUGGESTED, AN OVERRIDE SWITCH SHOULD BE PROVIDED TO ENSURE THAT NO LIGHTS ARE LEFT ON WHEN THE CLASSROOM IS UNOCCUPIED. IT SHOULD BE NOTED THAT PHOTOELECTRIC CONTROL IS NOT SUITABLE FOR SWITCHING HIGH INTENSITY DISCHARGE LAMPS BECAUSE OF THIER STARTING CHARACTERISTICS.

TIME CONTROLS CAN BE USED WHERE A SCHOOL CEASES TO BE OCCUPIED AT A FIXED TIME EACH DAY SO THAT THE TIME SWITCH WOULD SWITCH OFF MOST OF THE LIGHTS AFTER THE LAST OCCUPANTS HAVE LEFT THE BUILDING. AN OVERRIDE DEVICE TO PERMIT LIGHTING TO BE SWITCHED

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ON FOR FIXED PERIODS OF TIME SHOULD BE CONSIDERED IN THE INSTANCES FOR AREAS WHICH MAY GET EVENING USE, SUCH AS GYMNASIA.

THERE IS A MORE SOPHISTICATED PHOTOELECTRIC CONTROL NOW AVAILABLE WHICH IS USED FOR 'TOPPING UP' THE LIGHT IN THE SPACE.

THIS EQUIPMENT IS CONTROLLED BY A PHOTOELECTRIC SENSOR AND AS THE DAYLIGHT FADES THE ELECTRIC LIGHTING INCREASES; AS THE DAYLIGHT GETS BRIGHTER THE ELECTRIC LIGHTING IS REDUCED. IT DOES HOWEVER REQUIRE SPECIAL BALLASTS FOR FLUORESCENT AND HID LAMPS.

AN OCCUPANCY DETECTOR CAN BE USED TO SENSE THE PRESENCE OF PEOPLE IN A SPACE. IF NOBODY IS THERE, THE LAMPS ARE EITHER DIMMED OR SWITCHED OFF, USUALLY WITH A TIME DELAY BETWEEN THE LAST PERSON. LEAVING THE SPACE AND THE LAMP SWITCHING. HOWEVER, WHEN A PERSON ENTERS THE SPACE, THE LAMPS COME ON IMMEDIATELY.

IN ORDER TO MAKE THE MOST OF YOUR EXISTING LIGHTING SYSTEM SOME OF THESE ITEMS ARE PERHAPS WELL KNOWN. IN TODAY'S WORLD THEY ARE WORTH REPEATING.

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1. REMOVE UNNECESSARY LUMINAIRES

   IT IS RECOMMENDED TO REMOVE UNNECESSARY LUMINAIRES RATHER THAN MERELY REMOVING LAMPS BECAUSE A NUMBER OF LUMINAIRES WITHOUT LAMPS WILL TEND TO LOOK UNSIGHTLY AND A SYSTEM THAT LOOKS MAKE-SHIFT TODAY WILL PROBABLY GO ON LOOKING MAKE-SHIFT FOR THE NEXT FIFTEEN YEARS,UNLESS SOMEONE DOES SOMETHING ABOUT IT. REMOVAL OF LUMINAIRES TO REDUCE THE OVERALL LIGHTING MUST BE DONE VERY CAREFULLY IN ORDER TO MAINTAIN AN EVEN DISTRIBUTION OF LIGHT IN THE SPACE BEING CONSIDERED.

2. REPLACE LAMPS WHICH ARE BEYOND THEIR USEFUL LIFE. A BADLY BLACKENED FLUORESCENT LAMP, FOR EXAMPLE, PRODUCES JUST A SMALL FRACTION OF ITS RATED LIGHT OUTPUT AND STILL CONSUMES THE SAME AMOUNT OF POWER.

3. KEEP THE LUMINAIRES CLEAN AND REPLACE DISCOLOURED LENSES. IF YOU HAVE THE CHOICE, SELECT THE WORK STATIONS TO TAKE ADVANTAGE OF DAYLIGHT. CERTAINLY ONE CAN CONVERT TO MORE EFFICIENCY LAMPS, THE 35 W WATT MISER OR ENERGY SAVER IS AN EXAMPLE OF THIS AND IT CAN BE INSTALLED WITHOUT PROBLEM IN MOST LUMINAIRES IN SCHOOLS. IN USE OF THE MORE EFFICIENT

BALLASTS THERE IS SOMETHING THAT SHOULD BE CONSIDERED. SOME OF THE BALLASTS HAVE REDUCED THE BALLASTS' DRAW FROM 16W OR MORE TO 9W PER BALLAST. THE USE OF DUMMY OR "PHANTOM" LAMP CAN REDUCE THE POWER DRAWN BY A LUMINAIRE BY ABOUT 60%. IMPROVING THE SWITCHING SYSTEM IN YOUR SCHOOLS CAN INVOLVE ALL THE OCCUPANTS WITH TRAINING AND ENCOURAGEMENT TO USE LIGHTING ONLY WHEN IT IS NEEDED. KEY SWITCHES DISCOURAGE PARTICIPATION.

PAINT FINISHES IN THE SCHOOLS, WHEN BEING REPLACED, SHOULD HAVE A REASONABLE REFLECTANCE FACTOR IN ORDER TO MAXIMIZE THE LIGHT PRODUCED BY THE ENERGY FOR WHICH YOU ARE PAYING. LONG-TERM PAY-BACKS STILL ARE SHOWN BY THE TYPE OF SOPHISTICATED LIGHTING CONTROL SYSTEMS WHICH WE DISCUSSED EARLIER. THESE CONTROLS WILL BE JUSTIFIED IN NEW BUILDINGS WHILE ON A REPLACEMENT BASIS ARE STILL PROBABLY BEYOND MOST SCHOOL BUDGETS. DO NOT FORGET THAT YOUR OUTDOOR LIGHTING MAY WELL BE AN ENERGY HOG AND ITS USE SHOULD BE CAREFULLY CONTROLLED AND IN MANY INSTANCES THE LAMPS CAN BE REPLACED WITH OTHERS OF REDUCED WATTAGE. TIME CONTROL ON EXTERIOR LUMINAIRES IS IMPORTANT AS WELL AS KEEPING THE LUMINAIRES CLEAN.

NOW WHAT OF THE FUTURE? IN THE FUTURE MANY ITEMS WILL BE BROUGHT IN. THE USE OF DAYLIGHTING WILL BE FORMALIZED, QUANTIFIED, AND SUNLIGHT COLLECTED FROM OUTDOORS DISTRIBUTED THROUGH THE SCHOOLS BY LIGHT PIPES.

GLAZING WILL BE DEVELOPED WHICH WILL RESPOND TO CHANGING DAYLIGHT CONDITIONS; IN A SIMILAR MANNER TO THE GLASSES MANY OF US WEAR.

BEAMED SUNLIGHT WILL BE USED TO PROVIDE USEFUL ILLUMINATION IN SCHOOLS BY SUCH DEVICES AS REFLECTING VENETIAN BLINDS WHICH WILL PROJECT THE SUNLIGHT TO THE CEILING WHERE IT WILL BE DIFFUSELY REFLECTED ONTO THE WORK.

GREENHOUSES WILL BE BUILT ALONG THE WALLS OF THE SCHOOLS WHICH WOULD CAPTURE HEAT FROM THE SUN AND CAN BE USED TO WARM THE SCHOOLS.

SHUTTERS OVER THE GLASS WILL RETAIN THE HEAT AT NIGHT.

THE PRESENT I.E.S. ILLUMINANCE RECOMMENDATIONS, WHICH ARE BASED ON CONSENSUS, WILL GRADUALLY BE REPLACED BY RECOMMENDATIONS BASED ON SCIENTIFIC STUDY. LAMPS OF GOOD COLOUR RENDERING AND OF

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GREATER EFFICACY WILL BE DEVELOPED. THE THEORETICAL MAXIMUM EFFICACY OF A WHITE LIGHT SOURCE IS ABOUT 300 LUMENS PER WATT. THE MAXIMUM EFFICACY OF A PRESENT DAY WHITE LIGHT SOURCE IS ABOUT ONE QUARTER OF THIS VALUE.

HID LAMPS WILL BE INSTANT STARTING AND OF BETTER COLOUR RENDERING. LOW WATTAGE HID LAMPS, THAT DO NOT REQUIRE A SEPARATE BALLAST, WILL BE A DIRECT, HIGH-EFFICIENCY REPLACEMENT FOR INCANDESCENT LAMPS.

LIGHTING SYSTEMS WILL BE SPECIALLY DESIGNED FOR USE IN SPACES CONTAINING VISUAL TEACHING AIDS (SUCH AS THE VISUAL DISPLAY UNIT).

FINALLY LIFE-CYCLE COSTING WILL BE USED INSTEAD OF INITIAL COST IN DRAWING UP THE BUDGET FOR SCHOOL BUILDING AND OPERATING COSTS, WHICH WILL HAVE FAR REACHING EFFECTS ON THE LIGHTING SYSTEMS IN SCHOOLS.

FINALLY, FARTHER INTO THE FUTURE, PANEL LAMPS WILL BE DEVELOPED WHICH DO NOT HAVE TO BE DIRECTLY CONNECTED TO A SOURCE OF ELECTRICAL POWER. LIGHTING AND OTHER ELECTRICAL REQUIREMENTS WILL BE MET BY ON-SITE POWER GENERATION, WHICH WILL BE

SUPPLEMENTED, WHEN NEEDED BY POWER FROM THE LOCAL UTILITY.

LIGHTING FOR SCHOOLS IS A FASCINATING STUDY AND WILL BE WHAT YOU MAKE IT.

AUGUST 26/1982

NOTE: CIRCLED NUMBERS REFER TO 35MM SLIDES PREPARED FOR THE PRESENTATION

ALL SLIDES (PHOTOS) HAVE BEEN REMOVED

(EXCEPT NO. 10)

BECAUSE OF NON-REPRODUCABILITY.

ONTARIO MINISTRY OF EDUCATION

RECOMMENDED ILLUMINANCES 1982

KINDERGARTEN[1]	350 LUX
CLASSROOMS (GENERAL)	500 LUX
CLASSROOMS (VISUALLY IMPAIRED	1500 LUX
LARGE GROUP INSTRUCTION AREAS[2]	250 LUX
ABOVE FOR STUDY OR EXAMINATION[2]	500 LUX
CAFETERIA	
KITCHEN	500 LUX
SERVERY	350 LUX
GENERAL	250 LUX
ABOVE FOR STUDY OR EXAMINATION[2]	500 LUX
GYMNASIUM	
(GYMNATORIUM & CAFETORIUM)	
GENERAL	250 LUX
ABOVE FOR STUDY OR EXAMINATION[2]	500 LUX
DRAFTING - GENERAL	500 LUX
DRAFTING - ON BOARDS[3]	1000 LUX
GRAPHIC ARTS - GENERAL	500 LUX
GRAPHIC ARTS - ON BOARDS[3]	1000 LUX
LABORATORIES	
GENERAL	500 LUX
DEMONSTRATORS' DESKS	750 LUX
LIBRARY (STACKS)	250 LUX
SEMINAR ROOMS	500 LUX
READING,[3] CATALOGUING	500 LUX
OFFICES	500 LUX
MUSIC ROOM	500 LUX
SEWING[3]	500 LUX
SHOPS[3]	500 LUX
TYPING	500 LUX
WASHROOMS, LOCKER AREAS	250 LUX
CORRIDORS	
WITH LOCKERS	250 LUX
WITHOUT LOCKERS[3]	100 LUX
MECHANICAL & SERVICE AREAS	250 LUX
STORAGE AREAS	100 LUX

NOTES:

1. TASKS NOT SEVERE OR CRITICAL
2. SWITCHING CAN VARY ILLUMINANCE 50%
3. LOCAL SUPPLEMENTARY LIGHTING CAN BE PROVIDED FOR FINE WORK OR FEATURE DISPLAYS. LOCAL LIGHTING OFTEN DESIRABLE FOR STUDY CARRELS.

NOTE : 10.76 LUX = 1 FOOT CANDLE

SLIDE NO 10